China Planning Network (CPN) CPN Urban Transport Congress

Beijing July 19, 2008

DECISION-MAKING ON INFRASTRUCTURE PROJECTS: THE NEED FOR ALTERNATIVES AND OPTIONS

Professor Hugo Priemus,
Faculty of Technology, Policy and Management,
OTB Research Institute for Housing, Urban and Mobility Studies
Delft University of Technology
h.priemus@tudelft.nl

Abstract

There are many pitfalls in the decision-making process on infrastructure projects. There are problems with the costs, with the performance, the cost-benefit ratio, the legitimacy and the flexibility.
This paper deals with the early stages of the decision-making process. We argue that it makes sense to generate alternative solutions in an early stage, based on a valid problem analysis. In addition, we argue that it is crucial to have different options for the further realisation of the project. Given the long period between initiative and the delivery of the infrastructure project it is important to maintain flexibility in each stage of the decision-making process.

Keywords: Infrastructure project, alternatives, options, flexibility, decision-making process.

**DECISION-MAKING ON INFRASTRUCTURE PROJECTS:
THE NEED FOR ALTERNATIVES AND OPTIONS**

1. Introduction

Mega-projects cast a powerful magnetic spell on ambitious politicians. The thought of going down in history as the person who had the vision to start and perhaps even realise a mega-project is both tantalizing and irresistible. Many politicians will not have the good fortune to do both, because several decades are likely to elapse between the initial proposal, the decision to realise and the handover.
Recently, research and management practices have exposed other dimensions. Studies by Flyvbjerg *et al.* (2003), Pickrell (1992), Wachs (1989; 1990) and many others have revealed that mega-projects do not generate the political success that they should because so many things go wrong along the way. Hall (1981) even uses the expression: 'great planning disasters'. A lot has been written about the fact that, initially, the costs are often grossly underestimated and the (transport) benefits grossly overestimated. The result is usually a scenario of the 'survival of the unfittest' (Flyvbjerg, 2007): in other words, the project with the most underestimated costs and the most overestimated benefits is best placed to win political approval at an early stage. From the democratic perspective it is crucially important in the stages before the political decision-making to have reliable information on costs and benefits. Flyvbjerg has argued on numerous occasions for reference class forecasting (Kahneman, 1994): namely, the quantification of costs and benefits based on information from a series of comparable completed projects instead of an interim budget forecast that relates specifically to the project in hand.

This paper deals with the early stages of the decision-making process on mega-projects.
It is not uncommon in large infrastructure projects for a solution to present itself early – the solution which suits the initiators and which then heads off in search of a problem. Hence, the process rarely begins with a proper analysis of the problems involved and an impartial appraisal of the alternatives. Often, in the earliest phases, we see lobby groups hard at work mobilising support for a particular solution that is thought to be superior. Feasible alternatives are not even put forward, let alone analysed. Any alternatives proffered by opposing camps further down the line are usually too late. It is not unusual for the government to back the – supposedly – superior solution at an early stage. Alternatives that are suggested by others in later stages of the process are often whittled down to nothing.

This paper looks at the problem analysis at the initial stage of the decision-making process and at the general problem of alternatives that are not generated early on and are therefore not given serious consideration. Most of the time, the solution precedes the problem (Section 2). Section 3 presents the case for a valid problem analysis as a basis for decision-making. Section 4 concentrates on the generation and appraisal of relevant alternatives. Section 5 focuses on systems analysis, a well-known and trusted technique which has been around since the 1980s but has not been applied nearly enough in practice. Section 6 addresses the role of systems analysis in large infrastructure projects. Section 7 proposes to split the decision-making process in different episodes. Last but not least, Section 8 argues that it is vital to have different options during the preparation of a mega-project.

2. Jumping to conclusions: the wrong way

At the start of the decision-making process, the focus should be on the problem, not so much on the solution. In general, one can argue that a problem equals an objective plus an obstacle to achieving that objective. Generally speaking, the objective of creating an infrastructural connection in its simplest form is the linking of two points: towns/cities and/or regions. This is usually accompanied by further specification in the form of answers to certain questions: How many people and goods are transported or can be transported between a and b, and between b and a at present? How many people and goods need to be transported between a and b and b and a in the future (t_1, t_2, t_3 etc.)? How should this capacity be spread over 24 hours, the week (weekdays, weekend) and the seasons? How should the capacity of the existing infrastructure be expanded to achieve this? To what extent is a large new infrastructure project needed to achieve this end? How far does the capacity of certain modalities need to be modified? (For the transport of people, these are cars, trains and planes and, for short distances, buses, trams, the metro and bikes. For goods the modality options are trucks, trains, inland shipping, coastal shipping, planes and pipelines.) Do the traffic prognoses and the uncertainties that surround them make a large infrastructure project necessary all at once or would it be more appropriate to expand the capacity in phases?

In these situations it is essential not only to look at the linear connection between a and b, attention also needs to be paid to the level of infrastructure networks.

3. Moving towards a valid problem analysis

An infrastructure project is, at best, a solution. This implies that there are one or more problems to which an infrastructure project is the most expedient response. A valid problem analysis is essential in order to determine whether a proposed alternative is effective, efficient and legitimate. The first question that should be asked is: what is or what are the problem(s)? And then: what is the problem *now* and what is it likely to become in the short and the long term? And finally, who is affected by the problem? A problem for one party might be a solution for an other party.

Pretty soon the problem will emerge in the form of locations which are insufficiently accessible at present or in the future. This may go hand in hand with an increased risk of stagnation (measured in lost vehicle hours) due to growing congestion. Sometimes there are additional health and/or safety problems as a result of emissions (air quality).

As all of this impinges on mobility, people tend to see the problem in wider terms than just accessibility or stagnation. They refer to the decline in residential and commercial appeal and the prospect of a deteriorating living climate, less quality of life and a decline or stagnation in business leading to job insecurity and uncertain economic growth. This implicit connection between mobility and the living and economic climate is usually difficult to substantiate and often bears witness to a long list of policy ambitions which cannot be supported by valid insights.

In practice, it is barely possible – and usually impossible – to establish a causal relationship between improved accessibility and boosts to the regional economy (Rietveld, 1989; Vickerman, 1989; 2000; Banister & Berechman, 2000).

As problems are often perceived differently by different parties, it is not only essential to conduct a problem analysis but also to reach the strongest possible consensus. A generally shared problem analysis enhances the possibility that the selected alternative will still be endorsed by everyone in a later stage. If there is still a difference of opinion

on the analysis, it is usually the authorised political body who decides on the problems that will serve as the departure point.
Any later alternatives must be tested against the problem analysis. Hence, certain aspects need to be concretely and promptly specified, *viz*:
- the values and criteria;
- the objectives of the parties and the political bodies who bear responsibility;
- the boundaries and constraints.

The various parties may have different ideas about these issues, so a conflict can easily arise. The best approach is to identify potential stumbling blocks at an early stage and to establish a workable consensus.

4. Considering alternatives

Once the problem analysis has been sorted out, it is time to think seriously about potential solutions. It is best to appraise alternatives in the initial stages. After all, more than one road leads to Rome. An investment project is not always the right answer, so the Dutch Ministry of Transport, Public Works and Water Management (Ministerie van Verkeer en Waterstaat, 2004) differentiates between three types of solution, related to transport infrastructure: utilisation, pricing and building. First, attempts can be organised to make better use of the capacity of the existing infrastructure. Congestion might easily arise on certain routes during the rush hour. But can the capacity in the opposite direction be enlarged? Or the capacity outside the rush hours? That is the first question. The second is whether a price tag can be attached to the use of infrastructure in the form of a user charge or – more specifically – road pricing. Experience has shown that people curtail their use of infrastructure if it costs money. If the price is differentiated in terms of time and place, pricing can lead to a (better) utilisation. If utilisation and pricing are not enough, then new infrastructure or expansions to the current infrastructure can be considered.
The 'construction' category embraces various alternatives: different routes, different modalities (e.g. road, rail, inland shipping), different cross-sections (e.g. two-lane, four-lane, six-lane) and different types of integration (for instance, in order to conserve nature or prevent urban pollution).

It is imperative that alternatives are not put forward later by, for example, only opponents of the plan favoured by the government. Alternatives must be systematically recognised at a very early stage.

One factor that tends to be underestimated is the effect of prices and pricing policy. The demand for mobility cannot be satisfied without a price-tag. Without a price demand tends to be endless. So, the higher the price, the lower the demand. This is where the substitution of one modality for another becomes crucially important. If, for example, discounts bring about a sharp fall in the cost of air travel, then the demand for plane tickets will probably increase dramatically, but the demand for high-speed rail travel could plummet at the same time. The government plays a key role here – wittingly and unwittingly – through taxation and policy on user charges. Airlines do not pay VAT on kerosene, the concept of 'user charge' has been introduced into the train system, and many countries are considering road- pricing. Pricing-policy initiatives like these can have a deep impact on the development of mobility through a particular modality like the train. Evaluation studies ex post can determine how the use of infrastructure reacts on user charges (Affuso et al., 2003; Bonnafous, 2003; Bonnafous and Crozet, 1997; Nilsson, 1992; Quinet, 2000; Rothengatter, 2000; Priemus, 2005).

5. Systems analysis

For decades systems analysis methodology has shown how the decision-making on a new policy or project needs to begin by defining the problem. Certain questions need to be asked: What is the nature of the problem? Who is affected? Why is it a problem for one or more players?
The classic systems analysis procedure is shown in Figure 1. In section 6 we will apply it to the decision-making on a large infrastructure project.

[About here: Figure 1 The Systems Analysis procedure

Adapted from: Miser & Quade, 1985: 123.]

Figure 1 is drawn from Findeisen & Quade (in: Miser & Quade, 1985: 117-149), who provide an introduction and overview to the methodology of systems analysis.
Findeisen & Quade argue that besides formulating the problem, it is necessary to define the values and criteria and map out the boundaries and constraints. The next step is to devise solutions which best meet the objectives, values and criteria of the decisionmaker and other stakeholders, and take account of the boundaries and constraints. The alternatives are then identified, designed and screened.
Next, models are built to predict the long- and short-term consequences of each alternative according to the forecasts for, amongst others, demographic and economic trends and mobility dynamics. The impacts of each alternative are quantified on the basis of the models and assumptions. Finally, the alternatives are compared and ranked in advance according to their impact (costs and benefits). The results of the whole exercise are communicated clearly and over time. An important dimension is the awareness and quantification of uncertainties and risks.

[About here: Figure 2 The systems analysis procedure with iteration loops]

Adapted from: Miser & Quade, 1985: 124]

Figure 2 shows that, in reality, things are a lot more complicated than Figure 1 suggests, because many feedbacks with iteration loops are required. In addition, interaction between the analysis team and the decision-maker is essential. Figures 1 and 2 are basically twenty years old, making it all the more astonishing that systems analysis is so seldom used in current decision-making on large infrastructure projects.

Systems analysis is still useful as a methodology for decision-making on large infrastructure projects. It instils in us the crucial importance of meticulous and exhaustive problem analysis at the start of the process and the design, generation, appraisal and ranking of alternative solutions. The decision-makers who apply this procedure will not be confronted with solutions searching for a problem.

6. Systems analysis and decision-making on large infrastructure projects

What can systems analysis offer modern-day decision-making processes on large infrastructure projects? We follow and explain the boxes, presented in figure 1 and figure 2.

Formulating the problem
When an infrastructure project is being considered, the problem is usually formulated in terms of accessibility. This problem can manifest itself at the link level and at the network level. Sometimes it also has an economic dimension: perhaps new infrastructure will revitalise or boost the regional economy. A detailed analysis of the problem is both necessary and desirable at the start of a decision-making process. When different actors perceive different problems, energy has to be invested in communication and negotiations to reach a certain consensus about the problems perceived.

Identifying, designing, and screening the alternatives
The experience with the Betuwe Rail Link and the Zuiderzee Rail Link in the Netherlands illustrates how crucial it is that the players identify, design and screen the options at an early stage. There are alternative modalities (train, truck, inland shipping), alternative tracks and alternatives in time (including strong phasing of the alternative projects).

Building and using models for predicting the consequences
The effects of the alternative projects can only be determined *ex-ante* if realistic assumptions are made about the length of the period taken into account, the numbers of persons and/or volume of goods to be transported, the price the customers are willing to pay, the investment costs, the price to be paid for using the infrastructure, the costs of energy and maintenance for the infrastructure and vehicles, the trend in interest rates and inflation, the financing costs and about the costs of risk. As this exercise can lead to some heated debates, Flyvbjerg recommends (in: TCI, 2004) that the estimates be left to those players who have to bear the risks of under- and over-estimation. This recommendation certainly makes sense.

Comparing and ranking alternatives
Once the alternatives have been identified and fleshed out and the costs and benefits (priced and unpriced) have been established in each case, the alternatives can be ranked. A separate issue altogether is the allocation of the costs and benefits in time and across the various players. It is not uncommon for (some) benefits to accrue to parties – generally known as 'free riders' – who do not bear the costs. Sometimes the government can intervene so that the costs and benefits are redistributed in a fair way. But it is still perfectly conceivable that different rational players will arrive at a different ranking of alternatives, when they consider only their own costs and benefits.

7. Decision-making in stages

It is best to split the decision-making into five phases:

(1) The problem analysis: what is the problem and whom does it affect?

(2) The compilation of a functional programme of requirements: what criteria does the project have to meet?
(3) Elaborate the technical, functional and economic aspects and designate the project as ready for execution.
(4) The realisation of the project from the moment the first spade hits the soil to the handover.
(5) The operation of the infrastructure after completion.

When an initiative is launched to develop and realise a mega-project, it is prudent to approach the entire decision-making process (in particular phases 1, 2 and 3 above) as process with a learning curve. The brief is to gather as much relevant information as possible about the investment and management costs, the technical requirements and possibilities, the characteristics of the area that will be crossed by the project, the wishes, concerns, knowledge, determination and stalling capacity of the stakeholders, and the expected and sought-after development of transport flows and performances. The decision-makers will also have to ascertain the expected levels of energy consumption, noise and emissions and determine how these negative external effects can be contained to protect local residents, travellers and personnel.

Miller and Lessard (2008: 165-167) have a similar approach. He argues that projects are rarely shaped in one over-arching episode. He defines projects as paths of interdependent shaping episodes. Each shaping episode ends with a process of closure that suggests either abandoning the whole project or accepting a temporary agreement on a concept configuration. This means a go/no go decision after each shaping episode.
Multiple and interdependent episodes are necessary to resolve issues and arrive at a closure that, though reopenable, can be agreed upon. Episodes are not stages that logically flow from one to the other, but distinct shaping dynamics that are autonomous yet path-dependent (Miller and Lessard, 2008: 165).

8. Creation and exercise of options

Miller and Lessard (2008) stress the need for politicians and managers, involved in the development of a mega-project, to create and exercise a number of options during the whole decision-making process. In general, managers develop specific strategies to cope with foreseeable risks. However, they cannot develop specific ways to cope with 'surprise' events. Turbulence is likely to arise given the long time span required for development: think about changes in relevant markets and discontinuities in the policy-making process. Flexibility is provided by elements of institutional arrangements that enable projects to undergo rescheduling, restructuring, or bankrupty. The flexibility provided by institutional arrangements helps many projects survive unforeseen events (Miller and Lessard, 2008: 160).
The succession of shaping episodes that form the front-end process to cope with risks and surprises can be reinterpreted as a sequence of creating, shaping, and the exercising or abandoning of real options (Miller and Lessard, 2008: 171). Value is increased through the creation of options for subsequent sequential choices, and exercising these options in a timely fashion. Miller and Lessard (2008) illustrate the rich varieties of mechanisms through which these options are shaped and exercised over the life of the project – the real management that is integral to real options.

9. Conclusions and recommendations

Sörenson (oral presentation at a meeting of the University Council on Engineering Systems, Atlanta, USA, December 14, 2005) argues that the reason why most problems are never solved is because they are not formulated correctly in the first place. Far too often it is the wrong problem that is addressed. It is therefore imperative that each decision-making process for infrastructure projects start with a full problem analysis.

These flaws can be remedied by consistent application of systems analysis (Miser & Quade, 1985), which begins with a problem formulation and analysis and the identification of the objectives, values, criteria, boundaries and constraints that the stakeholders attach to the prospective solution. Alternatives are identified, designed and screened with a view to meeting these objectives, values, criteria, boundaries and constraints as far as possible. The assumed effects of each variable are determined with a model. The priced and unpriced costs and benefits are quantified with a cost-benefit analysis (Eijgenraam et al., 1999). The quantification of indirect effects is a particularly awkward business (Banister & Berechman, 2000; Elhorst *et al.*, 2004; Oosterhaven *et al.*, 2005). Finally, the alternatives can be ranked and the best one selected.

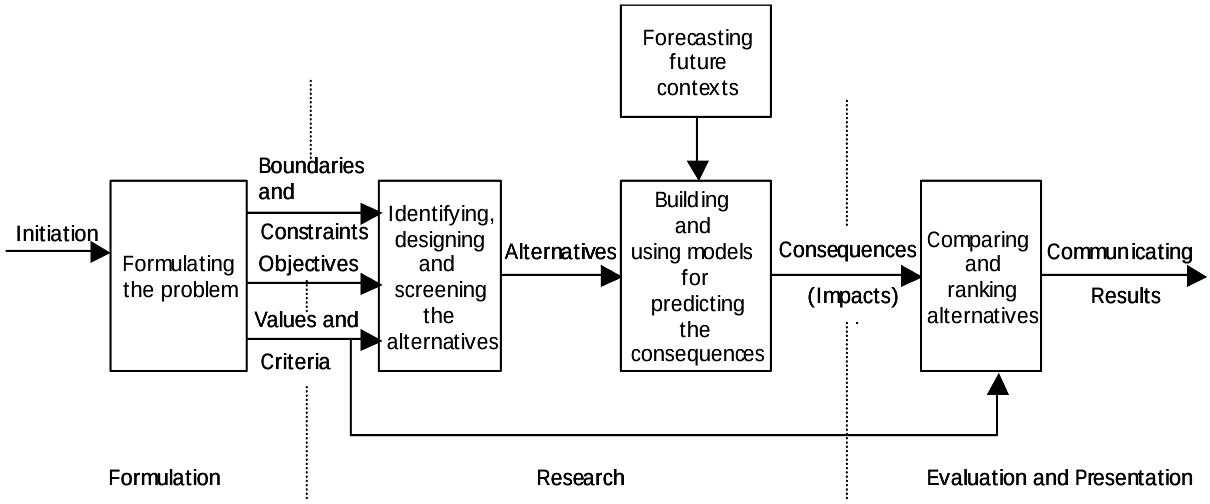
A sound structure of the decision-making process can be helpful to make clear where go/no go decisions by parliament or decentralised public representative bodies are needed to prevent entrapment or feelings of entrapment (Brockner and Zubin, 1985; TCI, 2004). Now that the European Commission is committed to develop Trans European Networks, including a European HST-network, the decision-making on large rail projects is gaining importance (ECMT, 2002; Sichelschmidt, 1999). Also the popularity of light rail transit systems (ECMT, 1994) confronts decision-makers with increasing challenges.

Systems analysis methodology as devised by Findeisen and Quade in 1985 still has a lot to offer as a basis for decision-making. Hands-on experience gleaned from numerous studies in Europe and North America has shown that systems analysis is rarely applied in decision-making processes on large infrastructure projects. It is important in the early phases to create plenty of scope for generating and working out alternatives. These would include options that would make the project unnecessary or too expensive as well as alternatives for the project itself. The integrity of the decision-making – and even of the democratic procedure – is enhanced when the rejected as well as the selected alternatives are known (and the respective reasons). The adoption of systems analysis still promises the best results in decision-making processes on large infrastructure projects.

In practice the decision-making is usually pretty chaotic; sometimes steps are retraced and decisions are reconsidered. It is absolutely crucial that a process architecture be designed beforehand and agreed by the parties. The above-mentioned division into five phases can help point the way. Each phase ends with a go/no-go decision. The problem analysis delivers a document which enables the competent authority to decide whether the next phase can begin: the *programme phase*, leading to a functional programme including the first estimate of costs, based on a reference class. If the functional programme leads to a 'go' decision, the *preparation phase* which leads to an execution decision (go/no go) can begin. A 'go' decision gives rise to fundamental commitments: the public and private funding is made available and the project is fleshed out in minute detail. The *execution phase* is followed by the operation decision and the *operation phase*.

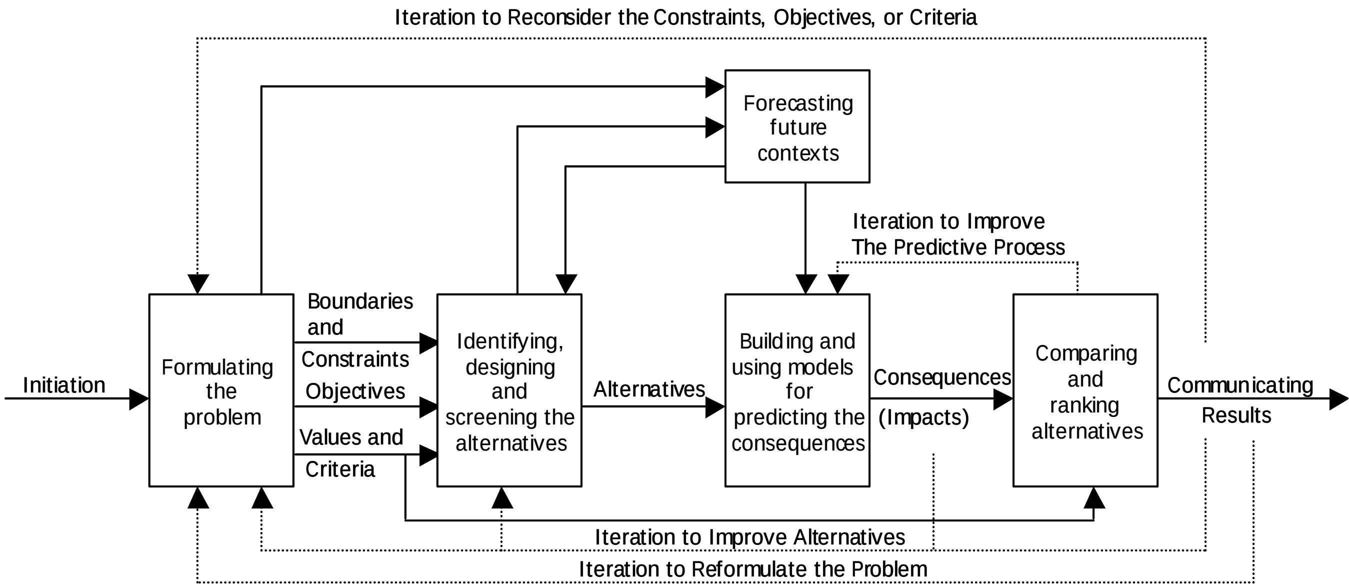
It is not inconceivable that part of a phase may have to be repeated; for example, the functional programme may need some adjustments to keep pace with insights that have emerged later. The phasing must always make clear which stage the infrastructure project has reached. It is very important to keep open as many options as possible so that unexpected surprises, new insights and changed circumstances can be tackled in a flexible way (Miller and Lessard, 2008). After seventy years with no lessons learned (Flyvbjerg *et al.*, 2003) it's time to get down to some serious work.

Figure 1 The systems analysis procedure



Adapted from: Miser & Quade, 1985: 123

Figure 2 The systems analysis procedure with iteration loops. (The figure does not show the essential ongoing interaction between the analysis team and the decision-maker.)



Adapted from: Miser & Quade, 1985: 124

References

Affuso, L., J. Masson and D.M.G. Newbery, 2003, Comparing investments in new transport infrastructures, **Fiscal Studies 24** (3): 273-315.

Banister, D. and J. Berechman, 2000, **Transport Investment and Economic Development**, London 2000.

Bonnafous, A., 2003, Assessing our expertise. In: European Council of Ministers of Transport (ECMT) (Ed.), **Fifty Years of Transport Policy. Successes and New Challenges**, Paris (ECMT).

Bonnafous, A. and Y. Crozet, 1997, Evaluation, dévaluation ou réévaluation des lignes á grande vitesse? **Les Cahiers Scientifiques du Transport 32**: 45-56.

Brockner, J. and J.Z. Rubin, 1985, **Entrapment in escalating conflicts: a social psychological analysis**, New York (Springer Verlag).

Elhorst, J.P., A. Heyma, C.C. Koopmans and J. Oosterhaven, 2004, **Indirecte Effecten Infrastructuurprojecten: Aanvulling Leidraad OEI** [Indirect Effects of Infrastructure Projects: Supplement to the OEI Guideline], Groningen/Amsterdam (University of Groningen/Foundation for Economic Research).

European Council of Ministers of Transport (ECMT), 1994, **Light Rail Transit Systems**, Paris (ECMT).

European Council of Ministers of Transport (ECMT), 2002, **European Integration of Rail Freight Transport**, Round Table Report, Paris (ECMT), vol. 125.

Eijgenraam, C.C.J., C.C. Koopmans, P.J.G. Tang and A.C.P. Verster, 1999, **Evaluatie van infrastructuurprojecten. Leidraad voor kosten-batenanalyse. Deel I: Hoofdrapport**, [Evaluation of infrastructure projects. Guide for cost-benefit analysis. part 1: Main report]. Onderzoeksprogramma Economische Effecten Infrastructuur (OEEI), The Hague (Ministerie van V&W en EZ).

Flyvbjerg B, 2007, **Truth and Lies about Megaprojects**, Inaugural speech, Delft University of Technology, September 26.

Flyvbjerg, B., N. Bruzelius and W. Rothengatter, 2003, **Megaprojects and Risk: An anatomy of ambition**, Cambridge (Cambridge University Press).

Hall P, 1981, **Great Planning Disasters**, Berkeley CA (University of California Press).

Kahneman D, 1994, New Challenges to the Rationality Assumption, **Journal of Institutional and Theoretical Economics**, 150: 18-36.

Miller R, Lessard D, 2008, Evolving Strategy: Risk Management and the Shaping of Mega-projects, in: H. Priemus, B. Flyvbjerg and B. van Wee (eds.), 2008, *Decision-making on mega-projects. Cost-benefit analysis, planning and innovation*, Cheltenham (UK), Northampton (MA) (Edward Elgar): 145-172.

Ministerie van Verkeer en Waterstaat, 2004, **Nota mobiliteit** [Memorandum Mobility], The Hague (Ministerie van V&W).

Miser, H.J. and E.S. Quade, 1985, **Handbook of Systems Analysis. Overview of Uses, Procedures, Applications, and Practice**, Chichester, New York, etc. (John Wiley & Sons).

Nilsson, J.E., 1992, Second-best problems in railway infrastructure pricing and investment, **Journal of Transport Economics and Policy 26** (3): 245-259.

Oosterhaven, J., C.C. Koopmans and J.P. Elhorst, 2005, Indirecte effecten van beleid: lastig, maar belangrijk [Indirect effects of policy: difficult but important], **ESB, 90**, 29 July: 335-337.

Pickrell, D.H., 1992, A desire named streetcar-fantasy and fact in rail transit planning, **Journal of American Planning Association, 58**, Spring no. 2: 158-176.

Priemus, H., 2005, Design & Construct bij de Hogesnelheidslijn-Zuid: De Wet van Murphy [Design & Construct for the Southern High Speed Rail Link: Murphy's Law], **Building Business, 7**, no. 1, February: 42-49.

Quinet, E., 2000, Evaluation methodologies of transportation projects in France, **Transport Policy 7** (1): 27-35.

Rietveld, P., 1989, Infrastructure and regional development: a survey of multiregional economic models, **The Annals of Regional Science, 23**: 255-274.

Rothengatter, W., 2000, Evaluation of infrastructure investments in Germany, **Transport Policy 7** (1): 17-27.

Sichelschmidt, H., 1999, The EU programme Trans European Network - a critical assessment, **Transport Policy 6** (3): 169-182.

Tijdelijke Commissie Infrastructuurprojecten (TCI), 2004, **Grote projecten uitvergroot. Een infrastructuur voor besluitvorming** [Large projects under the magnifying glass. An infrastructure for decision-making], Tweede Kamer 2004-2005, 29.283 nrs 5-6, The Hague (Sdu Uitgevers).

Vickerman, R.W., 1989, Measuring changes in regional competitiveness: the effect of international infrastructure investments, **The Annals of Regional Science, 23**: 275-286.

Vickerman, R., 2000, Evaluation methodologies for transport projects in the United Kingdom, **Transport Policy 7** (1): 7-16.

Wachs, M., 1989, When planners lie with numbers, **APA Journal**, 476 Autumn: 476-479.

Wachs, M., 1990, Ethics and advocacy in forecasting for public policy, **Business and Professional Ethics Journal**, **9**, (1&2): 141-157.